Feasibility of Single Palm Plot in Coconut Experimentation

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ABSTRACT. *The Coconut Research Institute (CRI) conducts about 8-10 long-term (>3 years) field experiments to improve the coconut cultivation in Sri Lanka. The most robust design in field experiments of coconut is the randomized complete block design (RCBD) with plot size varied from four to six palms. The blocking is done based on visual observation of the soil properties of the experimental field. It has now become a serious problem in finding homogenous plots within the blocks for experiments in coconut. This study illustrates the impact of using single palm plot data from concluded experiments. Based on data of seven concluded field experiments of coconut with a plot size of six palms, it was found that the single palm plot can be recommended for coconut experiments without changing inference obtained with the plot size of six, irrespective of the years and locations. The percentage increase of precision varied from 0.4 to 15.8%. However, it is clear that single palm plots are feasible for coconut experimentation. The methodology illustrated in this study can be used for other tree crops too.*

INTRODUCTION

The outcome of an experiment is affected not only by the effects of the treatment, but also by extraneous variation which tend to mask the effect of treatments. The term experimental error can be categorized into two parts; (i) inherent variability in the experimental unit or plot, to which the treatments are applied and (ii) lack of uniformity in the physical conduct of the experiment that is failure to standardize the experimental technique (Cochran and Cox, 1957).

In designing field experiments for coconuts, both experimenters and biometricians have to face many practical problems in selecting uniform areas of land, uniform plantations, uniform plot sizes and shapes etc. The most commonly used design in crop experiments of perennial like coconut is the Randomized Complete Block Design (RCBD). In comparison with other designs, RCBD has advantages on orthogonality, robustness and flexibility (Pearce, 1953). Adjacent plots, treated as alike as possible, will differ in as many characters. The causes for these differences are numerous. Among them the most important factor is soil heterogeneity. Previous experience has shown that it is impossible to identify a completely homogeneous experimental site.

The common approach of RCBD in field crops is random allocation of treatments to plots within the blocks. The blocks should be homogeneous and as small as possible and

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should be of the same compact shape. In coconut experimentation, blocks are generally done based on visual observation of the land by the experimenter and the Biometrician (Peiris, 2004). The most common problem by the experimenter in field experiments in coconut is lack of significant difference between the treatments in most of fertilizer and agronomic experiments. Since the efficacy of the field experiment depends on the experimental precision, early researchers (Abeysinghe, 1986; Abeywardena, 1964; Peiris and Salgado, 1937; Peiris and Thattil, 1997) have discussed various ways to increase the experimental precision for coconut trials.

Peiris and Salgado (1937) proposed the effective plot size as 16-18 palms to minimize the standard error of the experiment. It is not economical because nearly 0.1ha is required to represent a single plot consisting of 18 palms. Assuming coconut as a biennial-bearing crop, Abeywardena (1964) showed that the minimum plot size for coconut to be six palms. However, he pointed out that the intensity of biennial bearing is low in coconut. Abeysinghe (1986) showed that a plot size of four palms was sufficient for Completely Randomized Design (CRD) if the two-year pooled pre experimental yield is taken as covariant. But this is not practically possible, as two-year prior data in field experiment cannot be obtained always. Peiris and Thattil (1997) recommended an optimum plot size of four to six palms for long-term field experiments. In addition to the above methods, inherent variations can be also minimized to some extent using nearest neighbors analysis models proposed by Peiris *et al.* (2002).

In fact, in forestry experimental trials, Correll and Cellier (1987) considered single-tree plots techniques for some experiments. Therefore, the objective of this study is to investigate the feasibility of using single palm plot in coconut experimentation, using data from concluded field experiments in coconut.

MATERIALS AND METHODS

Secondary data

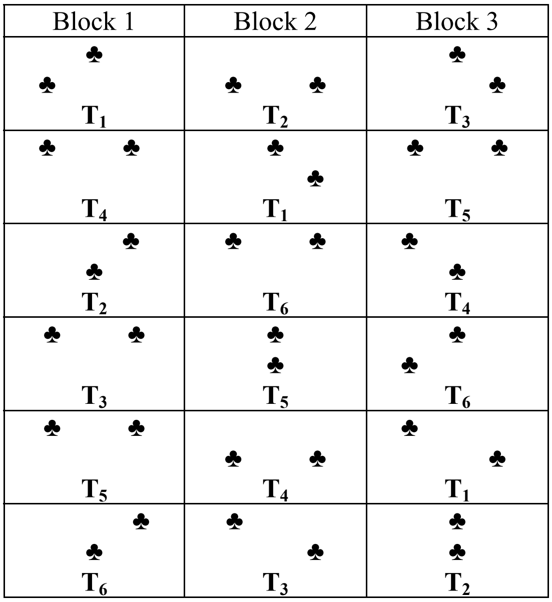
Palm wise data from seven concluded multi-location field experiments were selected from field experiment database maintained by the Biometry Division, CRI. The design of all experiments was RCBD with a plot size of six. Blocking was done on visual observations of the soil. Basic properties of each design are given in Table 1. The details of each experiment are given in Appendix A.

Table 1. Basic properties of the selected experiments.

Experiment	Location	Year/s	Number of blocks	Number of treatments	Plot size
1	Rathmalagara	1996-1999	3	5	6
2	Siringapatha	1996-1999	3	4	6
3	Thammanna	1996-1999	4	4	6
4	Wayagolla	1996-1999	4	4	6
5	Ambakelle	1997	3	6	6
6	Pottukullama	1997	3	6	6
7	Wayagolla	1998	3	5	6

Selection of single palm within a plot

As there are 18 plots of six palms in the experiment 1, 6^{18} combinations of single palm can be selected without changing the number of blocks. However, computing a large number of combinations is tedious and sometime not practicable. Hence, two palms within a plot were selected randomly and combinations of these two palms were used in the computation. With two palms per plot, 6^{18} combinations were reduced to 2^{18} combinations. The typical pattern of the selected palms is shown in Figure 1. The ANOVA was carried out and least square estimates were obtained for each combination of 2^{18} for other experiments as well (Cochran and Cox, 1957).



♣ – Coconut palm and
T – Type of treatment

Fig. 1. Spatial position of two palms selected from each plot in a RCBD with 3 blocks and 6 treatments of experiment 1.

Evaluating the precision in the new method

In this study, two indicators were used to measure the precision of the experiment namely (a) Coefficient of Variation (CV) and (b) the number of occurrence when treatments were significant. The computed CV for the original design was compared with the mean CV obtained under all combinations of a single palm design. Also, significance of pattern change of treatments was compared between the original design (with six palms) and modified design (with single palm).

RESULTS AND DISCUSSION

Analysis with plots of six palms

The CV obtained from the ANOVA for each year and location is given in Table 2.

Table 2. CV of initial field plan with plot size of six and status of significant of treatment.

Experiment	Location	Year	Serial number	Status of significant	CV (%)
1	Rathmalagara	1996	1	ns	26.4
		1997	2	ns	29.2
		1998	3	ns	33.3
		1999	4	ns	31.0
2	Siringapatha	1996	5	ns	27.2
		1997	6	ns	30.6
		1998	7	ns	29.7
		1999	8	ns	30.7
3	Thammanna	1996	9	ns	30.1
		1997	10	ns	31.0
		1998	11	ns	39.9
		1999	12	ns	37.2
4	Wayagolla	1996	13	ns	27.1
		1997	14	ns	26.3
		1998	15	ns	29.5
		1999	16	ns	29.4
5	Ambakelle	1997	17	*	31.2
6	Pottukullama	1997	18	**	30.1
7	Wayagolla	1998	19	*	28.7

Note: ns - not significant; *, ** indicates the significance at 5% and 1%, respectively.

According to the results in Table 2, it can be confirmed that out of 19 cases, significant difference between treatments was found only for three cases. Results further show that CV of each case is high irrespective of significance of treatment and varies from 26.3% to 39.9%.

Analysis with plots of single palm

ANOVA was also carried out for all possible combinations of single palm plot (with the same number of blocks and treatment as for the original design) for a given year in each experiment. The mean CV of the all possible combinations for a given year and given location is shown in Table 3.

Table 3. Mean CV of the all combinations of single palm plot within each experiment.

Experiment	Location	Year	Serial number	Mean CV (%)
1	Rathmalagara	1996	1	22.8
		1997	2	28.8
		1998	3	22.5
		1999	4	27.1
2	Siringapatha	1996	5	18.0
		1997	6	16.5
		1998	7	21.1
		1999	8	14.9
3	Thammanna	1996	9	29.3
		1997	10	26.4
		1998	11	38.8
		1999	12	36.2
4	Wayagolla	1996	13	26.0
		1997	14	25.8
		1998	15	27.3
		1999	16	27.2
5	Ambakelle	1997	17	17.4
6	Pottukullama	1997	18	21.1
7	Wayagolla	1998	19	20.2

When comparing the results in Table 2 and Table 3, it can be confirmed that CV of cases having single palm was significantly lower than the corresponding experiments with six palms. It indicates that the experimental error can be reduced by taking single palm plot irrespective of years and type of experiments. The percentage reduction of CV of single palm plot with respect to six palms plot varied from 0.4% to 15.8% (Fig. 2).

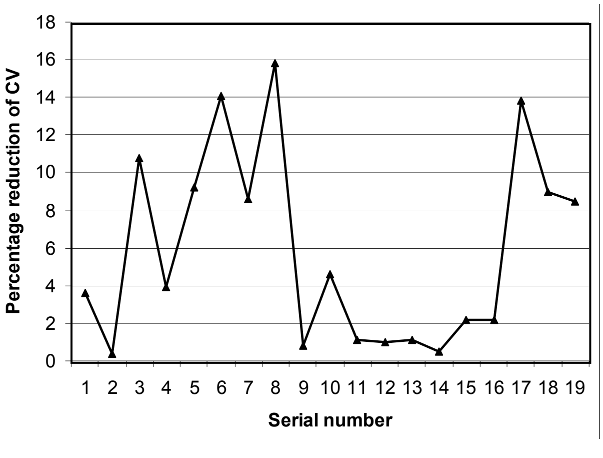


Fig. 2. Temporal variability of CV of six and single palm plot with reduction.

Effect of significance of treatment due to single palm

In the above analysis, it was shown that CV can be reduced when the number of palms in a plot was reduced from six to one. However, it was noticed the difference is not significance in all cases. Nevertheless, one is more interested to find out impact of significance of treatments when plot size was changed from six to one. In order to compare this, percentage number of significance cases and that of non-significance cases were computed with respect to all possible combinations used with single palms for a given year and a given location (for each case). The results are shown in Table 4.

Results in Table 4 indicate that even though the plot size reduced from six to one without changing the original design, the status of significance of treatments has not changed except in three cases (serial numbers 3, 15 and 18). However, such a thing can be ignored as extremely higher number of combinations ($>10^9$) was considered for each case of single palm design.

Table 4. Comparison of significance of treatments between six palms and one palm in percentage of 19 cases.

Serial number	Status of significance with plot size of six palms	Percentage of cases having single palm with treatment significant
1	ns	0.0
2	ns	1.1
3	ns	11.3
4	ns	7.8
5	ns	0.4
6	ns	8.3
7	ns	2.7
8	ns	1.6
9	ns	0.8
10	ns	0.7
11	ns	0.0
12	ns	0.0
13	ns	0.1
14	ns	0.9
15	ns	12.9
16	ns	3.2
17	*	93.4
18	**	82.7
19	*	90.5

Note: ns - not significant; *, ** indicates the significance at 5% and 1%, respectively.

The above results indicated that there is no difference of the inference obtained between plots of six palms and plots of one palm, in spite of additional cost to operate the experiments with six palms. In addition, conducting an experiment with single palm plot is more practicable compared to plots with six palms. In this methodology, number of blocks under single palm plot was kept as the same number of blocks under six palms plot. Therefore, it is worth to investigate the impact of single palm with respect to CV and status of significance of treatment by increasing number of blocks.

CONCLUSIONS

In coconut field experiments, the number of palms per plot can be reduced from six to one without affecting the precision of the experiment. In addition, the coefficient of variation with single palm has reduced substantially compared to that of a plot of six palms. The results clearly indicate that a single palm plot is feasible for coconut experiments. With respect to significant effects between treatments, no difference was found between plots of six palms and plots with single palm. Since the investigation was done only for a few concluded experiments, it is necessary to investigate more experiments before recommending single palm plots for all field experiments in coconut. Further, it is necessary to find the impact of single palms with a suitable covariate. The methodology illustrated in this paper can easily be used to find the feasibility of single palm for other tree crops, without conducting new trials.

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APPENDIX A

Objective and the treatments of each experiment

Experiment	Objective	Treatments
1 & 2	Substitution of inorganic nitrogen requirement of coconut palms	T_1-no fertilizer T_2-Adult Palm Mixture (APM) T_3-Gliricidia from outside + P & K T_4-Gliricidia in-situ + P & K T_5-cow dung + P & K (no control in experiment 2)
3 & 4	Evaluation of different fertilizer application techniques on the yield of coconut	T_1-no fertilizer but turning soil T_2-APM/turn/no mulch T_3-APM/turn/mulch T_4-Adult Coconut Mixture/Urea in dry period/turn/mulch T_5-APM in a 30cm wide, circular band, 60cm away from the palm/turn/mulch T_6-localized application of dug at 60cm distance from the palm and mulch
5	Comparison of different weed management systems and their effects on coconut yield	T_1-slashing and mulching T_2-slashing and removing the slash T_3-Glyphosate 2.88 kg /ha T_4-Glyphosate 1.44 kg /ha T_5-cover cropping T_6-unweeded
6	Study the effect of high density planted Gliricidia and Acacia under coconut for substitute of inorganic nitrogen of coconut palms	T_1-mulch with coconut fronds T_2-Gliricidia-density 1 (16 trees/coconut square) T_3-Gliricidia-density 2 (24 trees/coconut square) T_4-Gliricidia-density 2 lopping buried in ¼ circle trenches T_5-Acacia- density 1(16 trees/coconut square) T_6-Acacia- density 2(24 trees/coconut square)
7	Effect of chloride on coconut yield	T_1-control T_2-KCl – 1.6 kg/palm/year T_3-K_2SO_4 – 1.8 kg/palm/year T_4-NaCl – 1.2 kg/palm/year T_5-Na_2SO_4 – 1.45 kg/palm/year